From: "Lisa Kelly" <lkelly@crsi.org>
To: <wtc@nist.gov>
Subject: NIST NCSTAR 1 WTC REPORT COMMENTS

WTC Technical Information Repository
National Institute of Standards and Technology
Attention: Mr. Stephen Cauffman

Dear Mr. Cauffman:

Enclosed, from David P. Gustafson of CRSI, are comments on NIST NCSTAR 1 WTC Report. If you should have any questions, please feel free to contact me.

Best regards,

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NIST WTC Comments 080405.PDF

Comments on NIST NCSTAR 1
By
Concrete Reinforcing Steel Institute

General Comments

CRSI commends NIST for their extensive investigation of the WTC disaster. And for their "breadth-and-depth" reporting on the collapses of the WTC buildings. CRSI strongly supports the majority of NIST's recommendations. We would like, however, to call attention to several of the recommendations regarding exit enclosures (exit stairway shaft), uncontrolled burnout, and fire resistance for the structural frame.

Specific Comments

It is time to re-think and re-work the requirements for exit enclosures (stairways). As NIST reported, where the building occupants had access to an intact exit, the survivability of this terrorist act was nearly 100 percent, and on floors where the exit(s) were not intact the causality rate was nearly 100 percent. It should be clear that providing independent and remote exits is critical to the life and safety of the occupants. However current practice, consistent with the code provisions, often place exit enclosures (shaft) in the center of a building core, not necessarily remote from one another. The assembly forming the exit enclosure is commonly constructed of materials that only provide fire resistance and nothing structural. See exception 1 of Section 1014.2 and Section 1019.1 of the 2003 edition of the 2003 edition of the *International Building Code.*

We would like to call attention to the idea that certain structures need to be capable of resisting an uncontrolled burnout. From this incident, it can be seen that unforeseen circumstances do occur and automatic sprinkler systems may not be capable of providing fire suppression. Analogous to structural integrity and resistance to progressive collapse, building structures, in particular high-rise buildings, should have the necessary fire resistance to resist collapse in the event that the automatic sprinkler system fails.

We believe additional work is warranted in the area of "structural frames". This experience has drawn attention to the fact that fire resistance ratings are determined and assigned to idealized beams, columns, and wall/floor assemblies, and not to the actual construction itself. Some of the areas that should be investigated include connections, continuity of structural systems, durability of fireproofing, as well as the impact of the various connections through the fireproofing for the installation of mechanical systems.

CRSI agrees with the need to advance the technical base, as outlined by Recommendation 4, for improving the overall fire-safety of buildings. Achievement of these meaningful goals will require realistic fire resistance testing and modeling, as itemized in

Recommendation 5, and then followed by the adoption of appropriate provisions in codes and standards. Intuition says the conducting of realistic testing and implementation of the proper "fixes" in codes will require considerable time before they become a reality.

Tools and criteria now exist for implementing some level of rational design for the structural fire resistance of buildings. However, incentives are lacking in the current building codes to design a cast-in-place reinforced concrete building for structural fire resistance. Under the current building codes, considering floor slabs for example, the heat transmission criteria usually dictate the slab thickness required for a particular fire rating.

In the past, the State of Wisconsin maintained their building code, viz., the *Wisconsin Administrative Code.* The *Wisconsin Administrative Code* modified the heat transmission criteria in Section Ind. 51.042 — General Requirements:

> "(5) The heat transmission requirements of ASTM E119 (25b), with the exception of high hazard areas, penal and health care facilities and warehouses for combustible materials, may be reduced to one-half (½) of the hourly rating required by this code, but not less than one hour.
>
> (a) The fire-resistive rating for structural integrity required by this code shall be maintained where the heat transmission criteria has been reduced."

If current building codes had similar provisions as the former *Wisconsin Administrative Code,* that might encourage an Architect/Engineer to structurally design reinforced concrete floor slabs for fire resistance in certain occupancies. A detailed example of a continuous one-way floor slab in the CRSI book, *Reinforced Concrete Fire Resistance, is* quite revealing. The one-way slab system is designed to have a 3-hour structural fire endurance, assuming the heat transmission requirements may be waived or set at a lower rating. The 4.5-inch thick slab spans 15 feet c.-c. of supports; the service live load is 60 psf and the superimposed service dead load is 10 psf.

Two detailed structural analyses of the end span of the slab system are presented. The end span is the most critical for thickness. In the first analysis, the structural fire endurance is determined based on continuity only. The second analysis includes the beneficial effects of restraint to thermal expansion. The two analyses confirm the floor slab has a 3-hour structural fire endurance.

An evaluation of the reinforcement details is also included in the example — the required length of the top bars to resist negative moment at the first interior support is determined for the two analyses. The extension of the top bars at the first interior support for gravity loads is compared to the extensions required by the two analyses for structural fire endurance. For gravity loads, the top bars, #13 (#4) spaced at 9 inches on center, required at the first interior support are extended 4'–9" into the end span. Based on the continuity-only analysis for structural fire endurance, the top bars would have to be

extended 6'–11" into the end span. When the beneficial effects of restraint to thermal expansion are included, the second analysis for structural fire endurance, the top bars would have to be extended 5'–2" into the end span — about the same extension as that required for gravity loads.

Regarding materials, carbonate aggregate concrete is used in the slab. Concrete cover to the reinforcement is 0.75 inches. From Table 720.2.2.1 in the 2003 *International Building Code*, the 4.5-in. thick slab would have a 2-hour fire rating based on heat transmission. To achieve a 3-hour fire rating, using the empirical approach of the *IBC*, a 5.75 or 6-in. thick slab would be required (Table 720.2.2.1).

The analyses for structural fire endurance demonstrate that a 3-hour fire rating can be achieved with the 4.5-in. thick slab, which is the same thickness as that required for the gravity loads (strength and serviceability requirements).

Thus, CRSI urges NIST to consider including a recommendation in the report regarding short-term or near-term goals — to address the lack of incentives in current building codes for the rational design of structural fire resistance, and to encourage revising the current building codes so that the existing tools can be used effectively.

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The Concrete Reinforcing Steel Institute was founded in 1924 as a cooperative, non-profit organization of fabricators and producers of steel reinforcing bars and accessories. CRSI's main objective is to increase the use of steel reinforced concrete in construction. To meet this objective, CRSI conducts technical and marketing promotion efforts, as well as supporting research and engineering for the safe and proper use of materials in reinforced concrete construction.